Article

Economic valuation for an environmental improvement in Leon, Guanajuato

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Abstract

The present work addressed the problem of environmental pollution that exists in the municipality of Leon, Guanajuato. The metropolitan area of Leon is located in the seventh place of environmental pollution nationwide. The municipality has a population of 1 436 733 inhabitants and concentrates 27.7% of the total vehicular park of the state of Guanajuato and there is also established the most important footwear industry in Mexico, which is reflected in an environmental deterioration. Environmental pollution in Leon is considerable, since 57.2% of the surveyed population states that air quality is bad. This situation is reflected in the environmental deterioration and health problems of the inhabitants of the city. The main objective of the research has been to estimate the willingness to pay by the population of the municipality of Leon, Guanajuato, for the creation of a green fund to help mitigate the environmental problems of the municipality. To estimate the DAP, the contingent valuation method was used, for which surveys were conducted to the inhabitants of the city of León, in this way the necessary information was collected in order to obtain the DAP of the inhabitants of the city. The average DAP per inhabitant estimated was $131.15 pesos, earning an annual income of around $60 408 083.45 pesos; that is, $4 174 712.06 dollars in the year of 2014, taking as reference a vehicular park of 460 603 units (UAIP, 2015) for the same year.

Keywords: contingent valuation, environment, willingness to pay (DAP).

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Introduction

In this era of globalization, the concern for care, conservation of the environment and natural resources, has caused environmentalists, as well as those in charge of carrying out economic and social development policies, to focus their attention on this topic of such in this way, the levels in the quality of life of the people of the present and the future are not threatened by scarcity, degradation and contamination of natural resources.

Air pollution is a significant problem for urban areas with a high level of industrial development and a large vehicular park, which intensifies the concentration of various pollutants exposing the population to the dangers associated with health. This implies an increase in efforts to reduce levels of concentration of pollutants that have a negative impact on the health of the population and the ecosystem in general. This situation leads to an increase in costs for the care of human health incurred by the health sector and which directly affects the income of people who do not have a free medical service.

Air pollution in the city of Leon is mainly caused by the high concentration of population, the vehicle fleet and the leather industry. It is worth mentioning that Leon is the most populated municipality in the state of Guanajuato. According to demographic data, only in the municipality of Leon there is a total of 1 436 733 inhabitants, in addition it concentrates 26.2% of the inhabitants of the whole State and at the national level it is the 7th most populous municipality (INEGI, 2010). Among the pollutants that stand out in this municipality are sulfur dioxide, carbon monoxide, nitrogen oxide and total organic compounds (IEG, 2006).

In view of this situation, the government of the state of Guanajuato, through the Institute of Ecology of the State, assumes the responsibility of assessing and taking measures to improve the quality of the environment in the state, which is one of the most important environmental challenges faces this Institute. In order to achieve these purposes, an automatic air quality monitoring network has been integrated, in order to have a real diagnosis of the problem of air pollution in the Industrial Corridor area (Leon, Silao, Irapuato, Salamanca, Celaya), typified as critical by the Official Mexican Standard NOM-085-SEMARNAT-1994 (IEG, 2006).

The municipality of Leon has three automatic monitoring stations: the Chamber of the Footwear Industry of the state of Guanajuato (CICEG), the IMSS-T21 and the one of the Faculty of Medicine (FM). The monitoring stations of Leon are managed by the Institute of Ecology of Guanajuato and its operation is under the responsibility of the Technological University of León.

The municipality of Leon occupies the first place in the contribution of total pollutants at the state level, this clearly linked to the fact that it is the municipality of the State with the greatest amount of population and vehicular park, which is the main emitter of carbon monoxide (CO). On the other hand, it is the second place in emitting total organic compounds (COT), derived from the processes of tanning and use of solvents, coatings and glues used by the tannery and footwear industry (Figure 1).

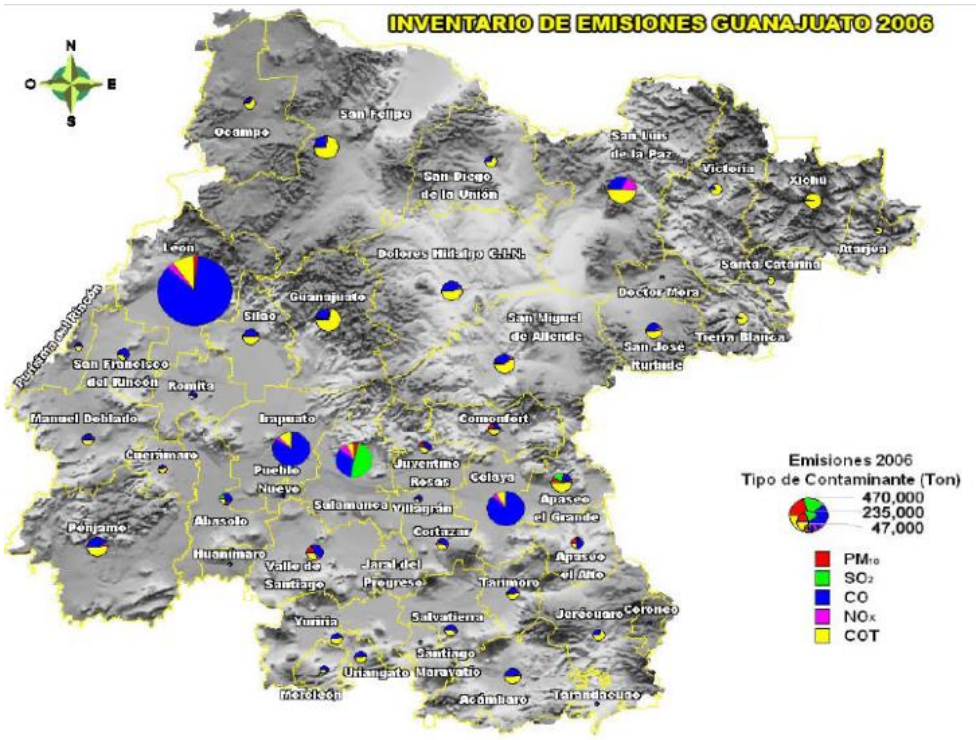

Figure 1. Inventory of emissions for the state of Guanajuato. Source: taken from the Guanajuato emissions inventory (2006).

Given the situation of a high concentration of carbon monoxide (CO) and a high emission of total organic compounds (COT), the authorities are already concerned about the possible damages they cause to the health of people and the environment in general, so the main objective of this research was to estimate the economic value for an improvement in air quality in León, Guanajuato by using the contingent valuation method (MVC).

At present, the contingent valuation method is the most used to make valuations of goods and services without a market. This method was consolidated through a favorable report from the commission of experts of the National Oceanic and Atmospheric Administration (NOAA), chaired by Arrow and Solow (Arrow *et al*., 1993). In 1993 the panel of experts was in favor of the method as a reasonable tool to calculate the value of non-use or passive use in the loss of welfare due to environmental disasters (Riera, 1994).

The studies to estimate the behavior and the revealed preferences of the consumers before an improvement in goods as in the quality of the water, that use the method of contingent valuation have found that the income, the educative level, the perception in the quality of the water and The living conditions of the home are statistically significant in the results of the model (Azdulbaki *et al*., 2008). This method has also been used to know the willingness to pay users of recreational activities in the Colorado River water flows, where they applied one hundred surveys to visitors, mainly from San Luis Río Colorado, conducted an econometric analysis of a single limit to the referendum question of availability to pay (Sanjurjo *et al*., 2007).

With regard to research aimed at analyzing aspects related to air quality, Osnaya (2002) made an analysis of the PROAIRE program of the Metropolitan Zone of the Valley of Mexico (ZMVM), where control measures are established to reduce emissions of greenhouse gases and local air pollutants. It was estimated that for the period of 2003 -2010, it is possible to save almost 700 cases of chronic bronchitis and other diseases derived from air pollution, which is reflected with a monetary benefit in public health in the order of US $200 million by year. Karimzadegan *et al*. (2008) conducted a study in which they concluded that air pollution affects human health in the city of Tehran, Iran, using the contingent valuation method, estimated the costs in health damages by the increase per unit of the following agents pollutants: US $16 224 for each unit increase in PM10, US $28 816 for each unit increase in CO_2, US $1 927 for each unit increase in NO_2 and US $7 739 for each unit increase in SO_2.

Burtraw *et al*. (2001) in a study to reduce the accumulation of greenhouse gases, through the reduction of fossil fuel use in the United States of America, indicate that among the main pollutants that harm human health are nitrogen oxides (NOx) and carbon dioxide (CO_2). They establish that with a tax of $25 per metric ton on the emission of coal, it would reduce the expenses for illnesses by approximately $8.00 per person per year. The increase in urbanization goes hand in hand with the increase in the deterioration of air quality (Wang and Zhang, 2008) as in the case of the city of Jinan in China, where by the low quality of the air and using the valuation method contingent, residents show that 59.7% of respondents were able to express a positive willingness to pay, and that the average DAP was 100 Chinese Yuan, per person, per year.

Materials and methods

The methodology used to carry out this research consisted in the use of the contingent valuation method to estimate the economic value of the air resource with the purpose of proposing the creation of a green fund to help improve air quality in Leon, Guanajuato In order to carry out the collection of the information, a simple random sampling (MAS) was carried out, through which the sample size was estimated, a questionnaire was subsequently developed and applied to the target population in a personal way.

For the estimation of the parameters of the logistic regression model, the logistic regression was used in order to estimate the DAP by the population of León, Guanajuato.

The contingent valuation method (MVC), is located within the direct - hypothetical methods that seeks to know the valuation that people make of the changes in the level of welfare, produced by a qualitative or quantitative change in the supply of a good environmental what is achieved through the application of questionnaires, where direct questions are asked under the assumption of the existence of an own market for these types of goods. It is considered that the management of these markets is completely comparable with the individual responses that are made in real markets (Mitchell and Carson, 1993).

In their origins, the theorists of environmental economics and natural resources, such as Mitchell and Carson (1989) developed the MVC contingent valuation method to measure the demand for an environmental good. In conventional economics, demand describes a relationship between the price of the good and the quantity purchased.

$$G = f(P, S)$$

Where: G is the amount of the good purchased; P the price of the good and S is a vector of economic variables that could affect the demand.

In the contingent valuation method, the researcher applies surveys to create a hypothetical market for the environmental good that is the subject of study. To do this, the good that will be valued is described, to later ask the interviewees how much they would be willing to pay and at the same time ask questions to obtain information about their socioeconomic characteristics. Once the information obtained from the surveys has been collected, the econometric analysis is done to subsequently construct the demand function of the environmental good from a regression that describes the price that the individual is willing to pay (DAP) for the consumption of the good and the characteristics socio-economic aspects of the interviewed individual.

The area under the demand curve is determined using the model described by Hanemann (1984). The model proposed by this author estimates the maximization of utility at the point at which the consumer is willing to accept a reduction in his income (I) by the amount of the price he would pay for the consumption of the environmental good in exchange for the utility that he receives compensates for his loss of income. This concept is shown in the following equation:

$$U(y_0, I; A) \leq U(y_1, I - P; A)$$

Where: U= the utility function of the consumer, which is a function of; y_0= the prevailing environmental conditions; y_1= improved environmental conditions from a policy or project; I= consumer income; P= the price of "offer" that the consumer would pay for the improvement of the environmental good; A= a vector of socioeconomic attributes that affect DAP.

However, it is not possible to observe all the components that influence the utility of the individual consumer. Therefore, it is assumed that utility is a random variable with an observable mean and a parametric distribution. Given this assumption, the random utility variable (V) is described as:

$$U = v(i, I; A) + \varepsilon$$

Where: v(%)= the value of the mean for U (•); ε= an unobservable component of the utility of the individual consumer, which is distributed independently and identically with zero mean.

The interviewed consumer will respond positively to the question about his DAP when the following condition is met:

$$v_0(y_0, I; A) + \varepsilon \leq v_1(y_1, I - P; A) + \varepsilon_1$$

The questionnaire used to gather the necessary information to try to estimate the DAP in the municipality of Leon, Guanajuato, contains socioeconomic variables such as: age of the respondent, sex, education, marital status, occupation, income, economic dependents. It also includes the perception of the environment describing the environmental scenario of the city of Leon, considering the contamination of water, air, soil erosion, loss of biodiversity, and

deforestation. The respondent is asked to order from 1 to 3, where 1 is "urgent" and 3 "less urgent", the environmental aspects that require greater attention in the municipality in the aspect of soil pollution and erosion, pollution and scarcity of the water and air pollution.

The respondent is asked if he knows of any public or private program aimed at improving the environmental situation in his region. He is consulted if he or someone in his family has become ill due to issues attributable to contamination, as well as the frequency. In the last section of the questionnaire they are asked about the willingness to pay (DAP), which is the elementary question of the contingent valuation.

According to Haab and McConnel (2002) there are several ways to obtain the willingness to pay. These authors propose four ways to obtain information and estimate preferences. Of those recommended by these authors, the cards of payment and the dichotomous or discreet choice are combined.

To determine the sampling units to which the questionnaires were applied, simple random sampling was used to carry out the survey, guaranteeing that all elements of the population have the same probability of being chosen (Cochran, 2000).

The level of confidence chosen was 95%, so the value of Z is 1.96; s^2 is the estimated variance of the pilot sample with a value of 68.12 and d2 which is the limit of the sampling error or standard error, takes the value of 12. The size shown calculated for the municipality of Leon was 125 observations, which is the number of questionnaires applied.

Econometric model

The statistical base of the econometric model that was used for this investigation starts from the logistic distribution, since the dependent variable is a qualitative variable the value is estimated from a logit model. The logistic regression model starts from the hypothesis that the data follow the following model:

Logistic regression model

$$\ln\left[\frac{p}{1-p}\right] = \beta_0 + \beta_1 * x_1 + \beta_2 * x_2 + \ldots + \beta_k * x_k + u = x * b + u$$

In order to simplify the expression, it is defined as z:

$$z = \beta_0 + \beta_1 * X_1 + \beta_2 * X_2 + \ldots + \beta_k * X_k$$

Therefore, the model can be represented as follows:

$$\ln\left[\frac{p}{1-p}\right] = Z + U$$

Clearing the quotient:

$$\frac{p}{1-p} = e^{z}$$

Where: p is the probability that it will occur to the study event. By operating algebraically on the equation, you get to:

$$p = \frac{e^{z}}{1+e^{z}}$$

As the logistic distribution function is:

$$F(x) = \frac{e^{x}}{1+e^{x}}$$

Therefore, you can rewrite the model much more compactly in the following way:

$$p = \frac{e^{z}}{1+e^{z}} = F(z) = F(x * b)$$

Where it follows that the logistic regression model is a non-linear regression model, but is linear in logarithmic scale corresponding to the original definition:

$$\ln\left[\frac{p}{1-p}\right] = Z$$

$$\ln(p) - \ln(1-p) = z$$

$$\ln(p) - \ln(1-p) = \beta_0 + \beta_1 * x_1 + \beta_2 * x_2 + \ldots + \beta_k * x_k$$

That is, the difference in the probability of an event occurring with respect to not occurring is linear, but on a logarithmic scale. Therefore, the meaning of the coefficients, although keeping a certain relationship with the linear regression model, will be somewhat more complex to interpret (Rojo, 2007).

The logistic model for this case is the following:

$$P(SI) = \beta_0 + \beta_1 * X_1 + \beta_2 * X_2 + \beta_3 * X_3 + \beta_4 * X_4 + \beta_5 * X_5 + \beta_6 * X_6 + \beta_7 * X_7 + \beta_8 * X_8 + \beta_9 * X_9 + \beta_{10} * X_{10} + \beta_{11} * X_{11} + \varepsilon$$

The meaning and description of the variables is provided in Table 1.

Table 1. Specification of the variables included in the model.

Variable	Denomination	Description	Explanation	Scale
Prob(Si)	P(si)	Probability of saying YES	Probability of answering YES to the question of availability to pay	Dichotomous 1= yes 0= not
Prepr	X_1	Predetermined price	Hypothetical price to be paid randomly assigned	Price assigned according to the design of the payment card
Age	X_2	Age of the interviewed	Years old	Continua
Sexo	X_3	Sex	-----	Dichotomous 1= male 0= female
Esc	X_4	Scholarship	School grade	Ordinal From 1 to 6 according to the level of schooling
Eciv	X_5	Civil status	-----	Dichotomous 1= Married 0= Single
Ing	X_6	Monthly income	Monthly income received by the family	Ordinal More than $12 001= 5 $9 001-$12 000= 4 $6 001-9 000= 3 $3 001-6 000= 2 0-$3 000=1
Tafa	X_7	Size of the family	People that make up the family	Continua
Prioamb	X_8	Environmental priority	Of the three natural resources (water, soil and air) which is the most urgent to attend	Ordinal 1= if people consider air is more urgent, 0 = if people do not consider the air as urgent but to another resource
Caliair	X_9	Perception of air quality	If contamination levels are very noticeable for the population	Dichotomic 1 = if the air quality is considered good 0 = air quality is not considered good
Cspro	X_{10}	Knowledge about a mitigation program to the problem of environmental pollution	If the population knows a public or private program to improve air quality	Dichotomous 1 = if they know any program, 0 = do not know any program
Enfe	X_{11}	Diseases	If any member of the family has become ill due to air pollution	1 = if you have fallen ill 0 = you have not fallen ill

Results and discussion

The results obtained from the survey in relation to the socioeconomic variables are the following: 61% of the respondents belong to the male sex, while the remaining 39% are female. Regarding the age of the interviewees, 28% are between 18 and 25 years old, while 14% are between 36 and 45 years old. With respect to schooling, 34% have high school studies. The predominant marital status in the surveyed population is married with 64.8%. Regarding the income variable, 55.2% of the population reported obtaining income between $3 001- $6 000 pesos. 56.8% of the interviewees consider that it is more important to treat the problem of water pollution than that of air (34.4%) Table 2.

Table 2. Value in percentage of the socioeconomic variables included in the model.

Variable	Criterion	(%)
Sex	Male	61
	Female	39
Age	More than 56	8
	Between 46 and 55	12.8
	Between 36 and 45	14.4
	Entre 26 and 35	36
	Between 18 and 25	28.8
Scholarship	I do not study	8
	Primary	12.8
	High school	32
	preparatory school	34.4
	University	12.8
Civil status	Married	64.8
	Single	35.2
Income	Less than $ 3 000	17.6
	Between $3 001 and $6 000	55.2
	Between $6 001 and $9 000	15.2
	Between $9 001 and $12 000	6.4
	More than $12 001	5.6
Environmental priority	Soil	8.8
	Water	56.8
	Air	34.4

Source: elaboration with results of the surveys.

Of the negative responses to the DAP, 8 are mainly related to economic issues (47.06%) and 6 that represent 35.29% of the negative responses. The population considers that the government should be in charge of solving the environmental problem Table 3.

Table 3. Reason why you are not willing to pay.

Reason	Results	(%)
For economical reasons	8	47.06
Do not trust the proper use of funds	3	17.65
The government should address these types of problems	6	35.29
He has no interest in the subject	0	0
Total	17	100

Source: elaboration with results of the surveys.

Econometric results

To perform this procedure, the computational package of Statical Analysis System 9.0 (SAS) was used, applying PROC LOGISTIC procedures. The results were interpreted following Allison (1999) and Greene (2003). The convergence status message of the model indicates that the numerical solution converged. The econometric results are shown in Table 4.

Table 4. Results of the logistic regression.

Parmeter	DF	Estimator	Standard error	Chi-squared	Pr>Chi squared
Intercept	1	5.9403	2.806	4.4817	0.0343
Prepr	1	-0.0177	0.0727	0.0594	0.8075
Edad	1	0.00058	0.0244	0.0006	0.981
Sexo	1	-0.7059	0.6965	1.0272	0.3108
Esc	1	0.3995	0.3127	1.632	0.2014
Eciv	1	-0.9226	0.7774	1.4086	0.2353
Ing	1	-0.8169	0.2777	8.6556	0.0033
Tafa	1	0.00577	0.2481	0.0005	0.9815
Prioamb	1	0.5808	0.6541	0.7885	0.3745
Caliair	1	-1.7988	1.2535	2.0592	0.1513
Cspro	1	-2.0634	0.9964	4.2885	0.0384
Enfe	1	-0.1094	0.7665	0.0204	0.8865

Source: elaboration with SAS output.

At the individual level it is observed that none of the variables is significant at the usual levels of statistical significance of 90%, 95% or 99%. However, they are kept at the respective level of trust because of their importance from the economic point of view.

In the case of discrete binary choice models, it is common to use the concept analogous to the coefficient of determination R^2 that explains the overall fit of the model, for which the statistic called pseudo R^2 of McFaden is used. According to Greene (2003) this statistic can be calculated by the following expression:

$$R^2 = 1 - \frac{LnL}{LnL_0}$$

Where: LnL is the likelihood function with the restriction that all parameters are equal to zero and LnL_0 the same function for an unrestricted model, which is calculated as follows:

$$LnL = n\big(PLnP + (1-P)Ln(1-P)\big)$$

Where: P is the proportion of affirmative responses to the DAP (p= 0.864) and n is the sample size (n= 125), substituting values is:

$$LnL = 125\big(0.864Ln(0.864) + (1-(0.864))Ln(1-(0.864))\big)$$

$$LnL = -49.7044$$

The value of LnL is obtained from the SAS output of -2LnL= 82.509. When clearing LnL, we have a value of LnL= -41.2545. Substituting the values of LnL_0 and LnL in the McFaden pseudo-R^2 formula, the following value is obtained:

$$R^2 = 1 - \frac{LnL}{LnL_0}$$

$$R^2 = 1 - \frac{-41.2545}{-49.7044} = 0.17$$

The value of R^2 is low (0.17), which means that 17% of the DAP is explained by the variables included in the model, but this level of adjustment is common in valuation work, for example, Tyrväinen and Väänäen (1998) obtained a value of R^2= 0.15.

To estimate the DAP_{media}, the following expression was used:

$$DAP_{mean} = -\frac{\alpha}{\beta} = -\frac{2.32128792}{-0.0177} = 131.15$$

Where α is the sum of the coefficients of the variables multiplied by their mean including the independent term and β is the value of the coefficient PREPR with negative sign. Therefore, an average DAP of $131.15 pesos is estimated, with a probability level of 91.06% of a positive response from the DAP. The probability was obtained by replacing the values of coefficients and the average values of the variables in the following expression:

$$p = \frac{e^z}{1+e^z} = \frac{e^{2.32128792}}{1+e^{2.322128792}} = 0.9106$$

Where z=β

Conclusions

The population of León, Guanajuato positively values the improvement of environmental quality. In the study, an average DAP of $131.15 pesos per inhabitant was estimated for the reduction of pollution in the municipality of León, Guanajuato, for a single annual payment. This allows to obtain annual income of $60 408 083.45 pesos; that is, $4 174 712.06 dollars in the year of 2014, for the formation of the green fund to mitigate pollution, taking as a reference a vehicle fleet of 460 603 units for the same year. The population of León, Guanajuato, believes that it is more important to address the problem of water pollution than air pollution, so the public body in charge of the environmental issue should review the water quality conditions of the municipality.

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